

Mobile Bay Sediment Modeling for Ecosystem Health Evaluation



MSFC/SSC Coastal Applications Project Team

- Mr. Maurice Estes, Jr., USRA/MSFC
- Dr. Mohammad Al-Hamdan, USRA/MSFC
- Dr. Jean Ellis, SSC previously/USC
- Dr. Dale Quattrochi, NASA/MSFC
- Ms. Callie Hall, NASA/SSC

Other Partners

- Dr. Ron Thom, Battelle/PNNL
- Ms. Roberta Swann, Mobile Bay National Estuary Program
- Ms. Chaeli Judd, Battelle/PNNL
- Dr. Dana Woodruff, Battelle/PNNL
- Mr. Steven Davie, Tetra Tech Engineering

Funding for this Project is provided by the NASA Applied Sciences Program, John Haynes Program Manager

Project Background

- Previously, coastal resource managers in Mobile Bay and other areas recommended that temperature and salinity modeling be supplemented with data on total suspended solids (TSS)
- Sediment influence on light attenuation is a critical factor in the health of submerged aquatic vegetation
- Overarching goal is to support NASA's Applied Sciences Program and utilize Earth observations to address coastal health issues

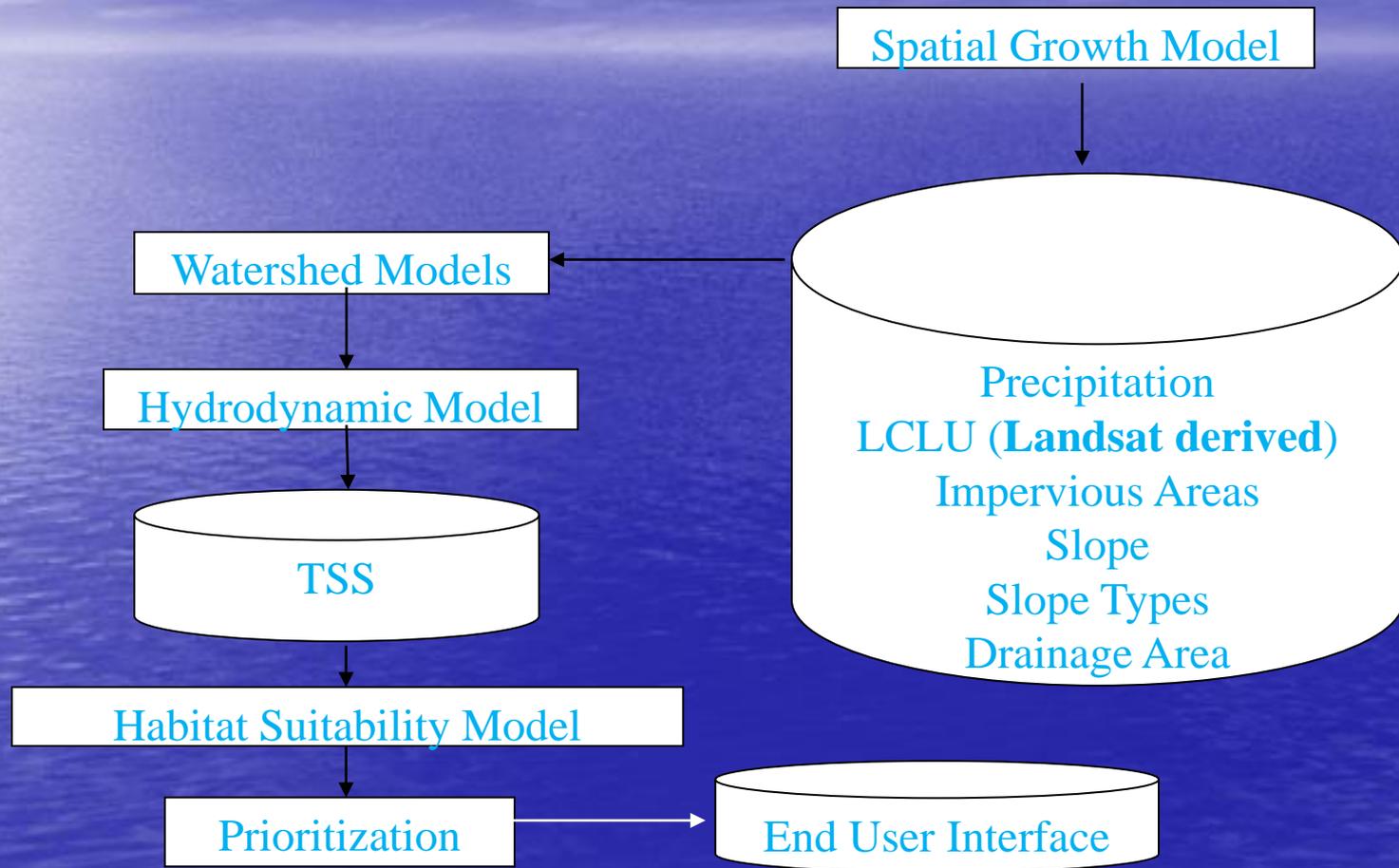
Outline

- Project Objectives
- Project Methodology
- Results
- Conclusions

Project Objectives

- The overall goal is to determine a measure for turbidity that can be used to evaluate the health of the aquatic ecosystem.
 - Model TSS for the Mobile Bay study area for a three year period (2003-2005) using four Land Cover Land Use (LCLU) scenarios
 - Evaluate LCLU impacts on TSS values
 - Perform statistical analyses to determine fluxes of TSS at strategic locations in the Bay
 - Use in-situ and TSS modeled outputs to model habitat suitability for seagrasses and submerged aquatic vegetation (SAV)
 - Share results with policy and decision-makers

Project Methodology



Model Scenarios

Baseline (1992)

Watershed - LSPC
Hydrodynamic - EFDC

“Present” (2001)

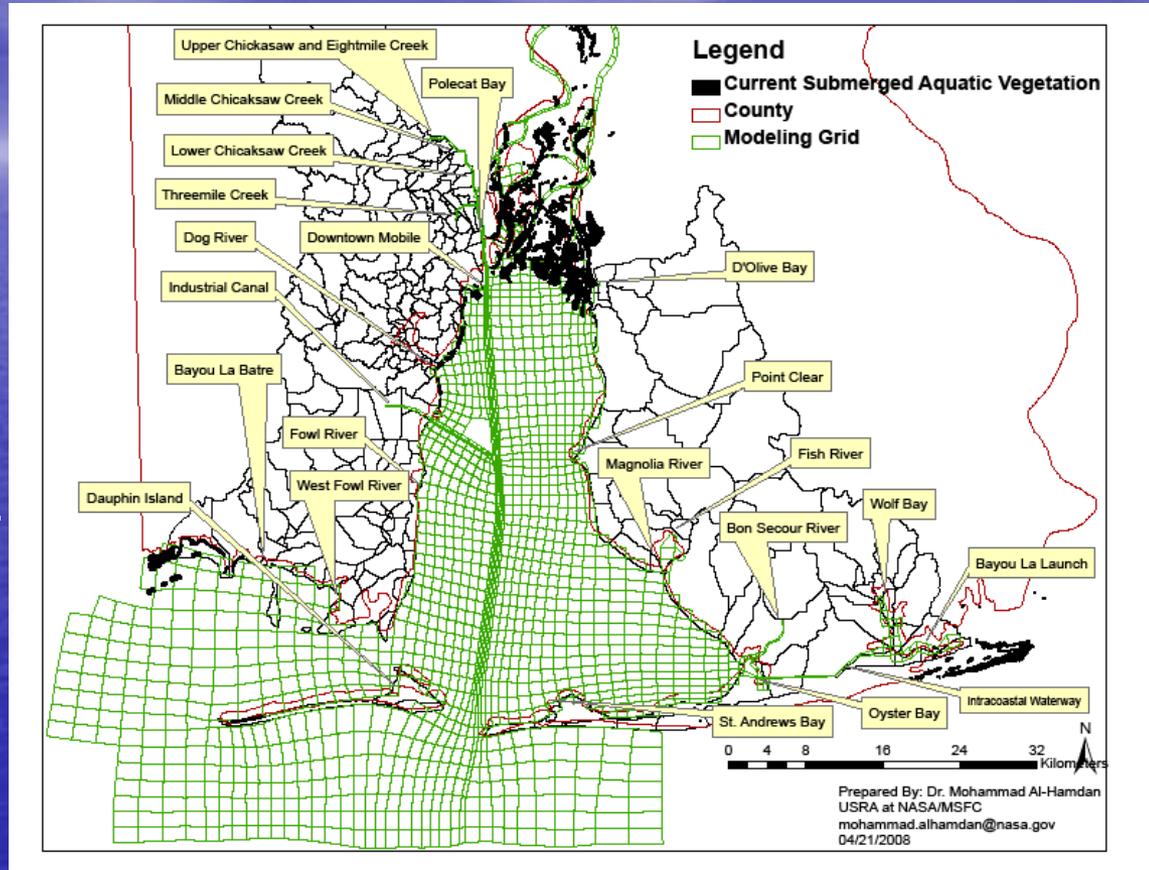
Watershed - LSPC
Hydrodynamic - EFDC

Forecast (2030 BAU)

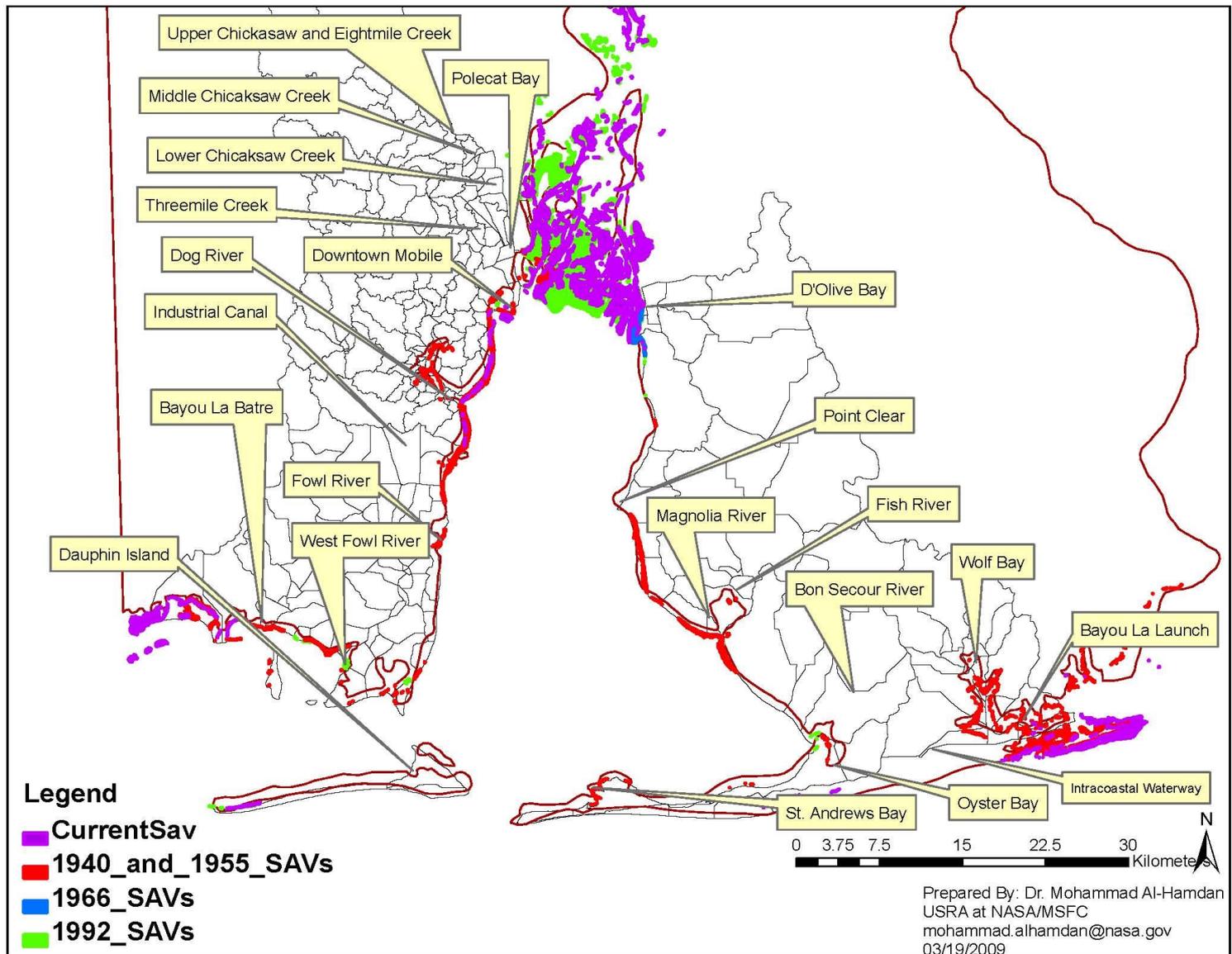
Watershed - LSPC
Hydrodynamic – EFDC

Historic 1948

Watershed - LSPC
Hydrodynamic - EFDC



Historical Submerged Aquatic Vegetation Distribution



Submerged Aquatic Vegetation

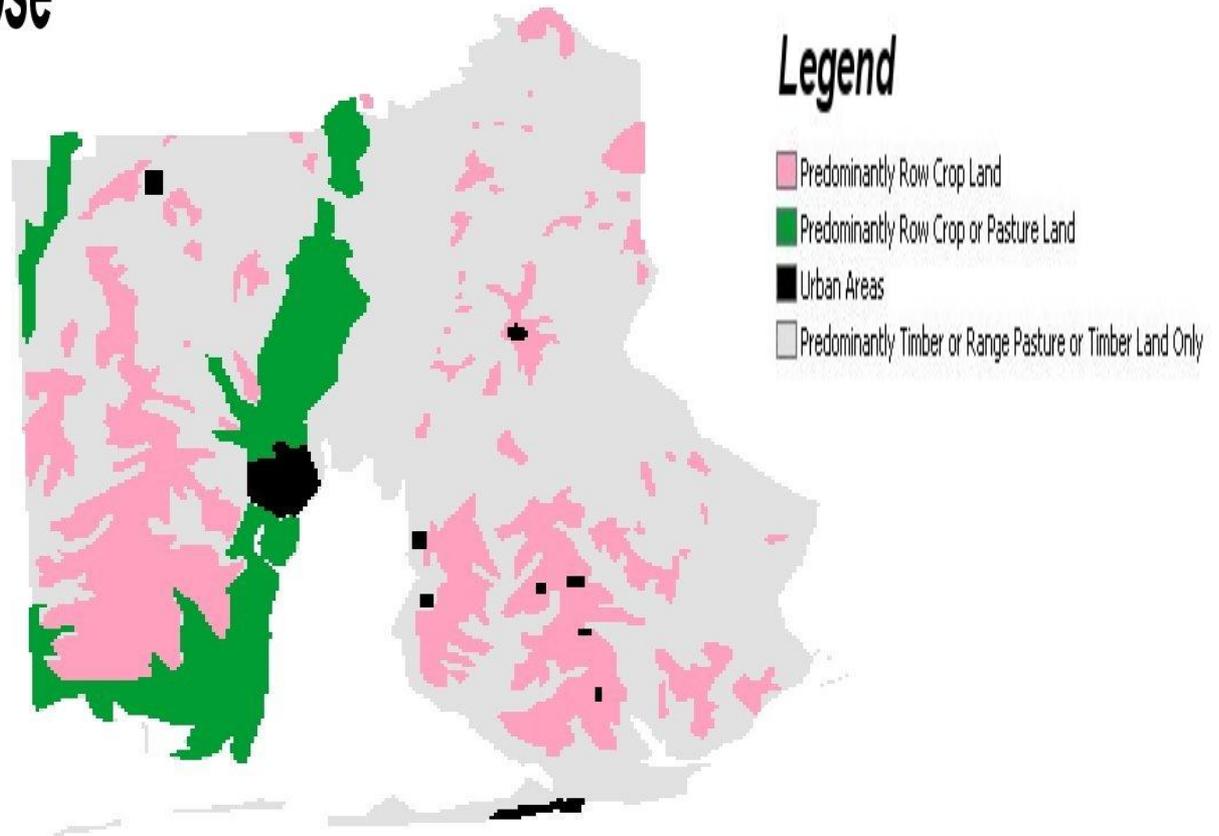
- Grow in shallow waters
- Provide critical habitat for crabs, fish, birds
- Structure to hold & trap sediments
- Range limited to areas which receive sufficient photosynthetically active radiation (PAR)
- PAR levels change with turbidity
- Used as indicators of water quality in some coastal areas (eg. Tampa Bay)



Ruppia maritima Photo credit: UMCES

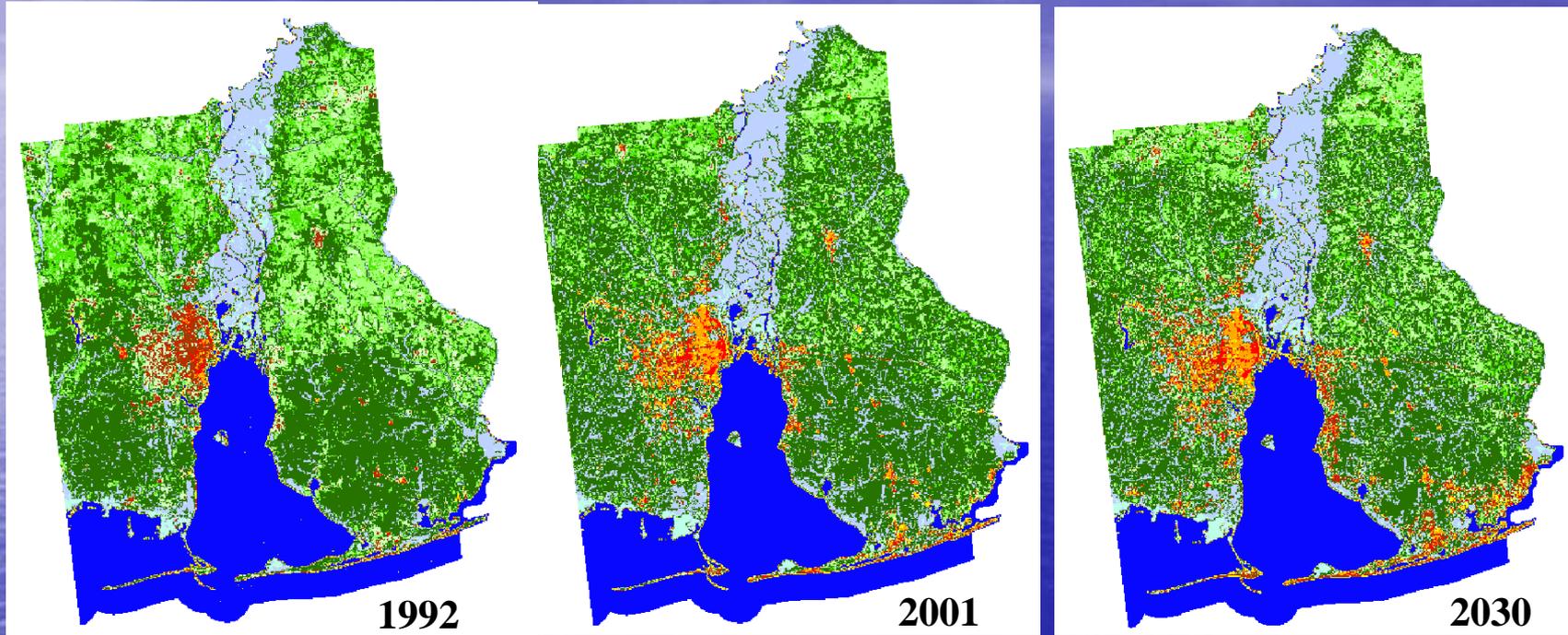
Historical LCLU Scenario

1948 Land Use



Source: State of Alabama

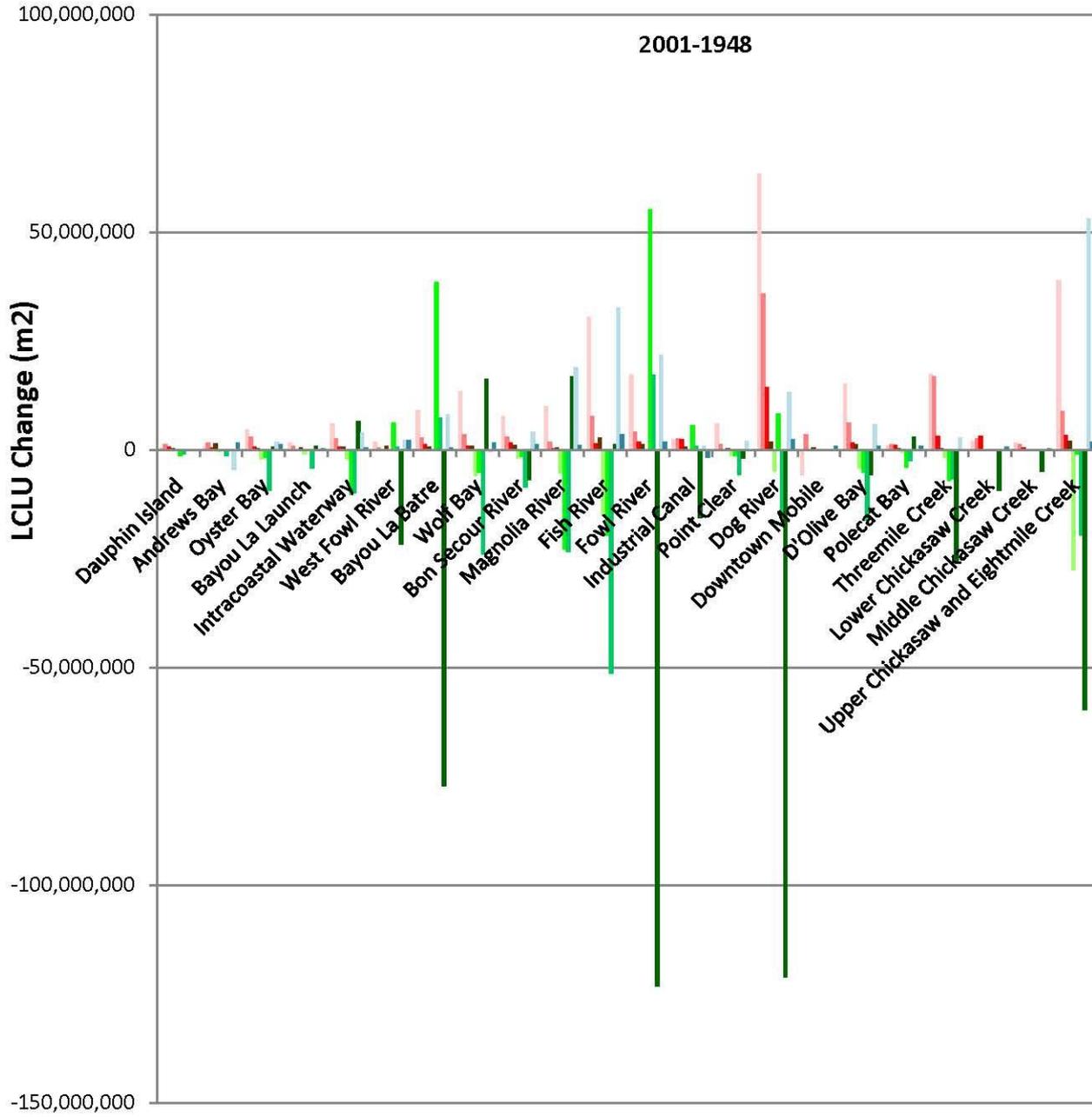
LCLU Scenarios



Results

- Land Cover Land Use Analysis
- TSS Change Analysis
- Impact of TSS changes on Seagrass and SAVs in Aquatic Ecosystems

2001-1948



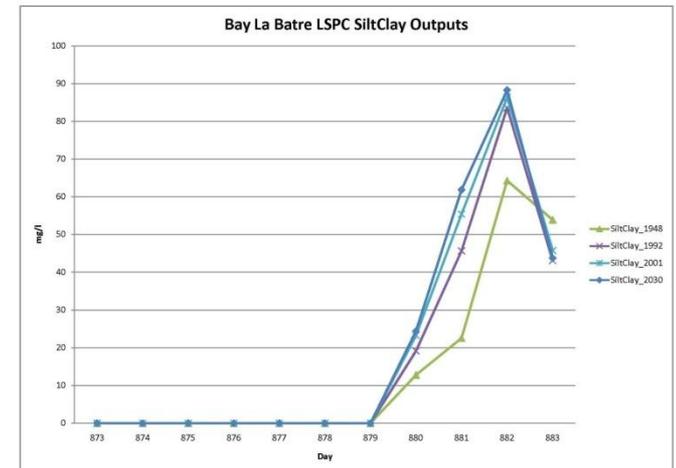
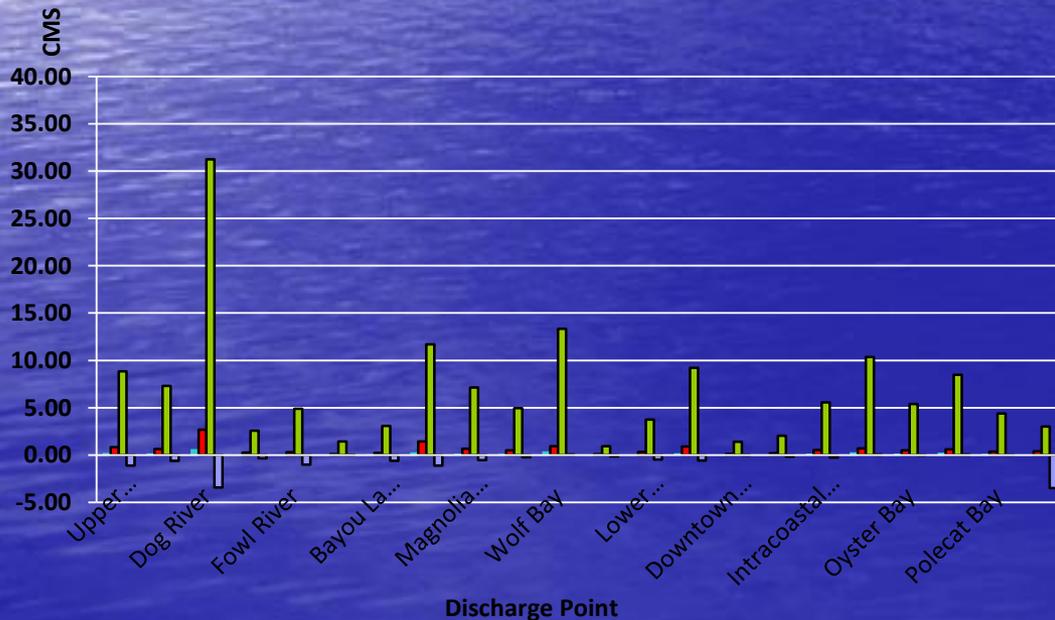
- Urban Low Density Residential/Recreation
- Urban Medium/High Density Residential
- Urban/Commerical
- Bare Soil/Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest/Shrub
- Agriculture/pasture
- Woody Wetlands
- Emergent Herbaceous Wetlands

LCLU Change and Total Suspended Solids

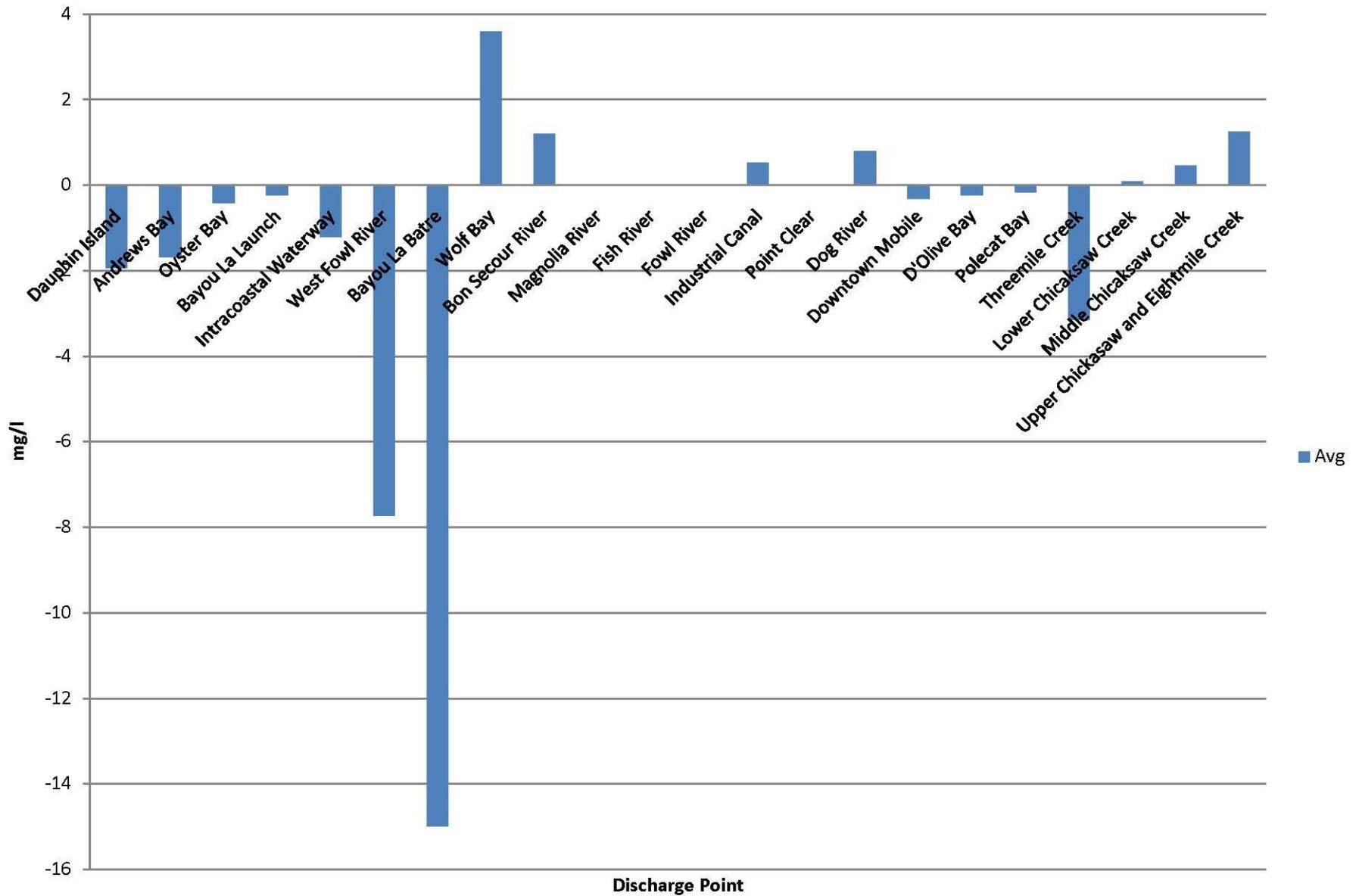
- Increasing Urbanization and Agriculture/Pasture decreases = - TSS
- Increasing Urbanization and Forest decreases = + TSS
- Increasing Agriculture/Pasture and decreasing forest = +TSS

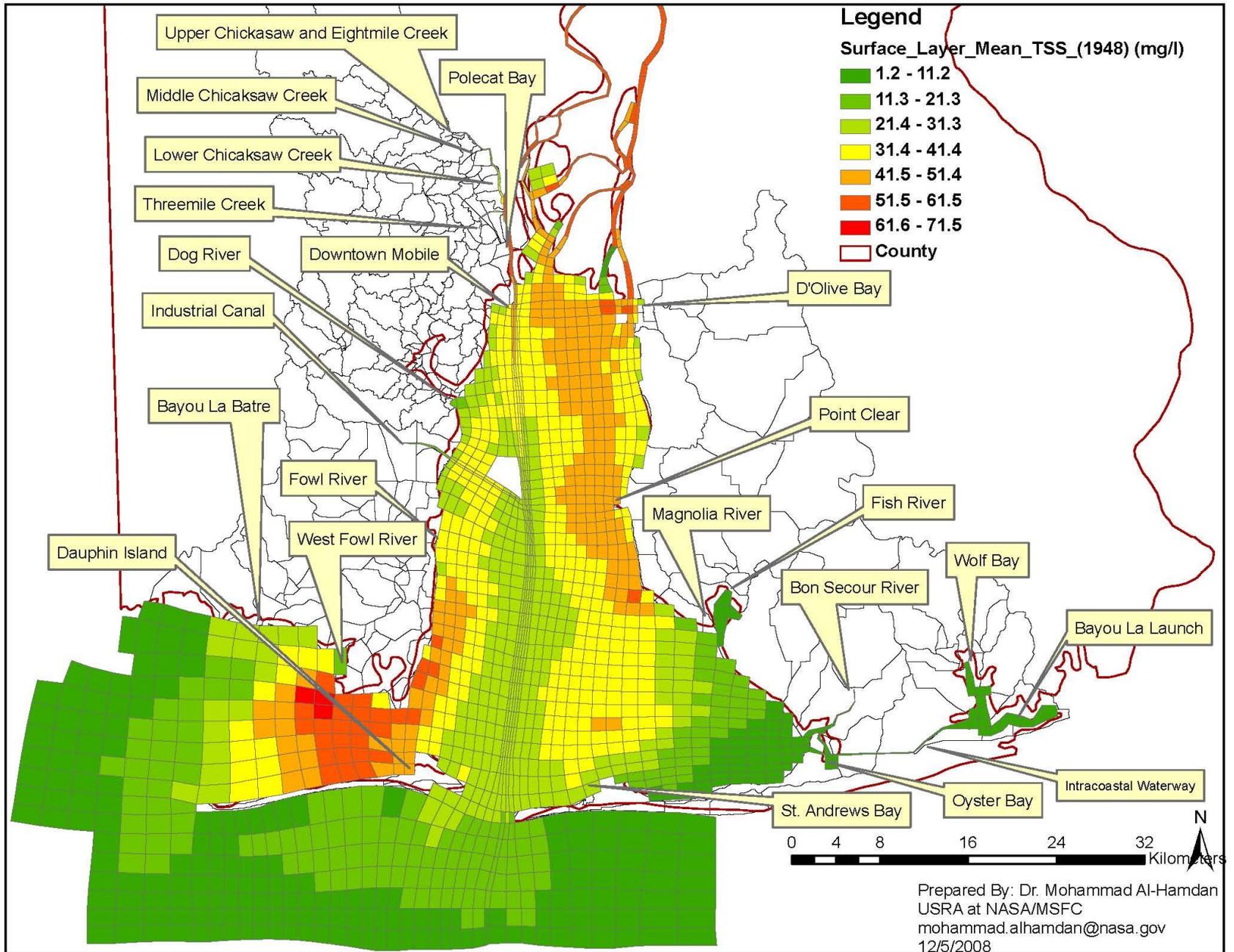
Total Suspended Solids (TSS)

- Result of soil conditions and precipitation events
- Mobile area is among wettest in the U.S.
- Climate data used in model is representative of normal or typical climate
- Silt/Clay 90 percent and sand 10 percent

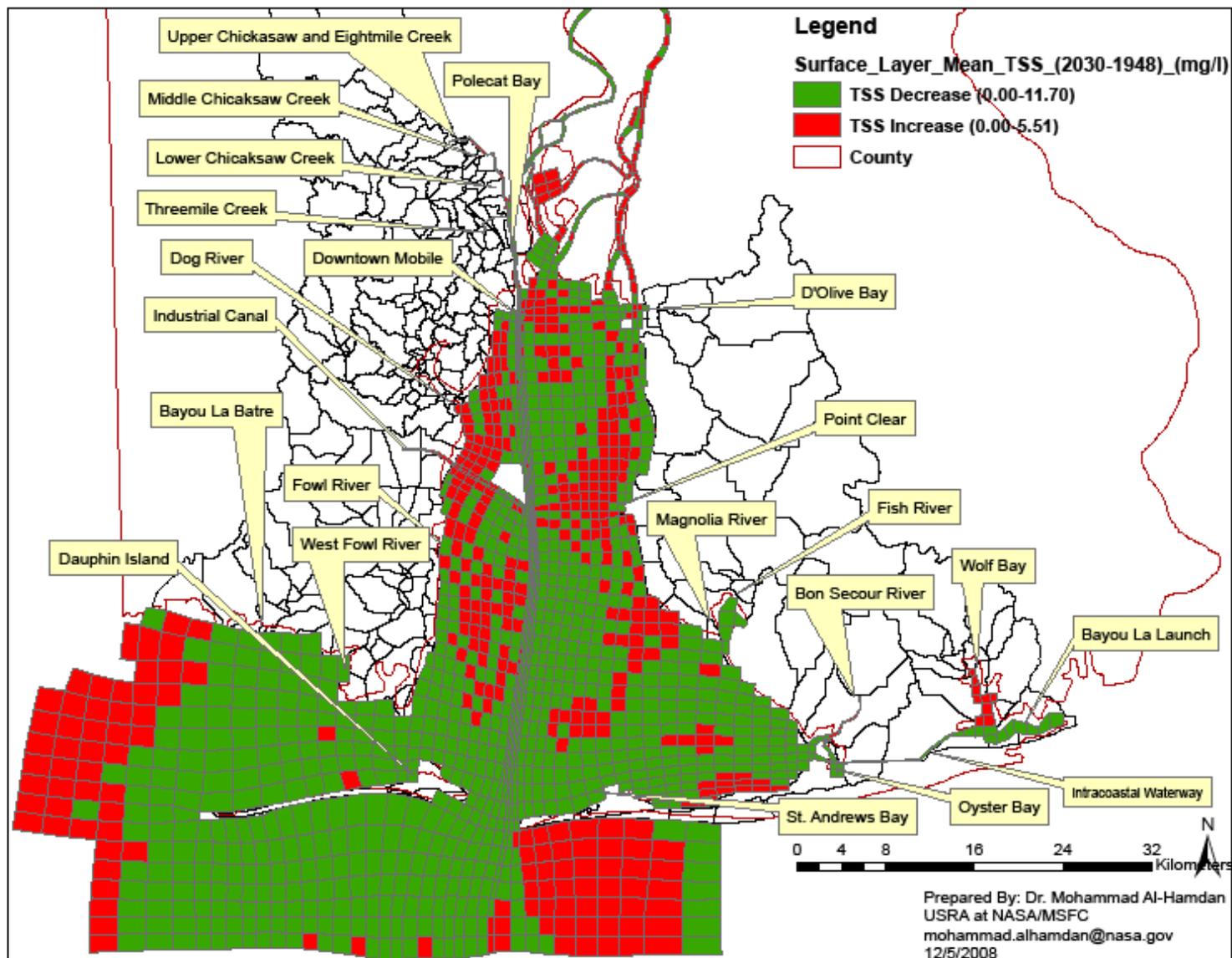


Mean Column TSS Differences (2030-1948)



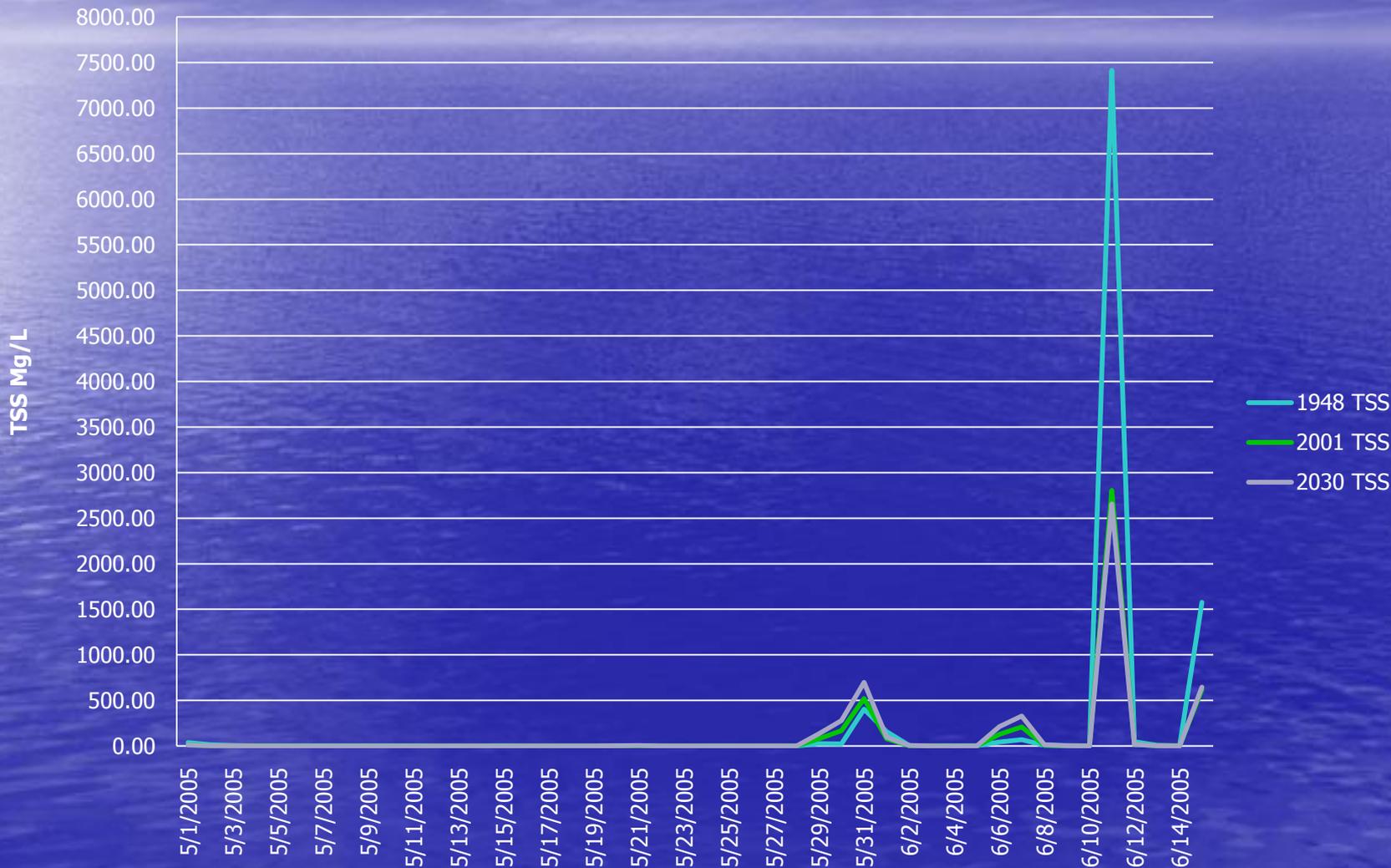


Change in TSS Spatially 2030-1948 LCLU



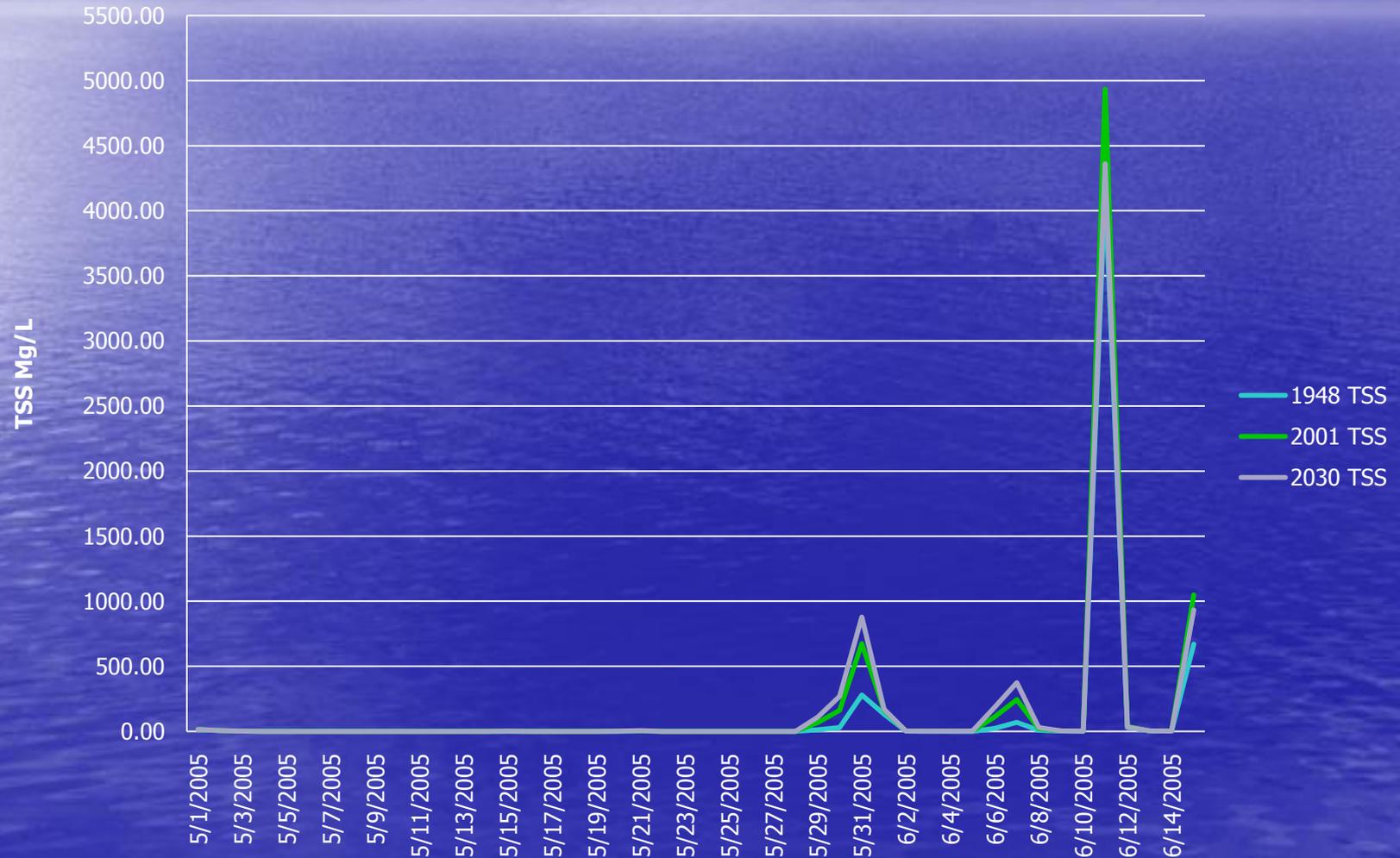
TSS Fluxes by LCLU Scenario and Wet vs. Dry Conditions

TSS for Bayou La Batre



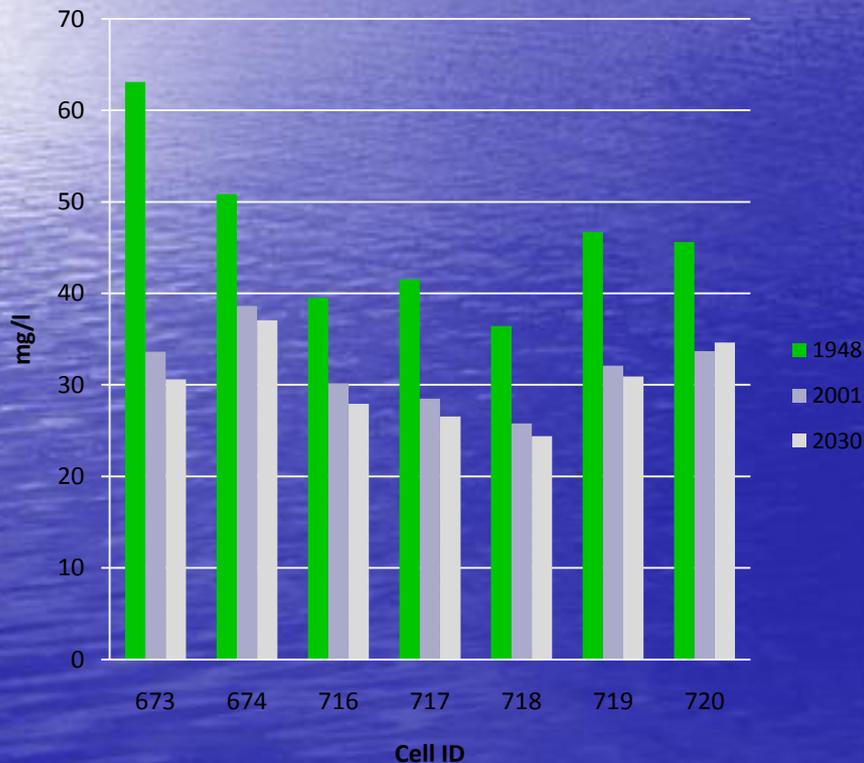
TSS Fluxes by LCLU Scenario and Wet vs. Dry Conditions

TSS for Wolf Bay

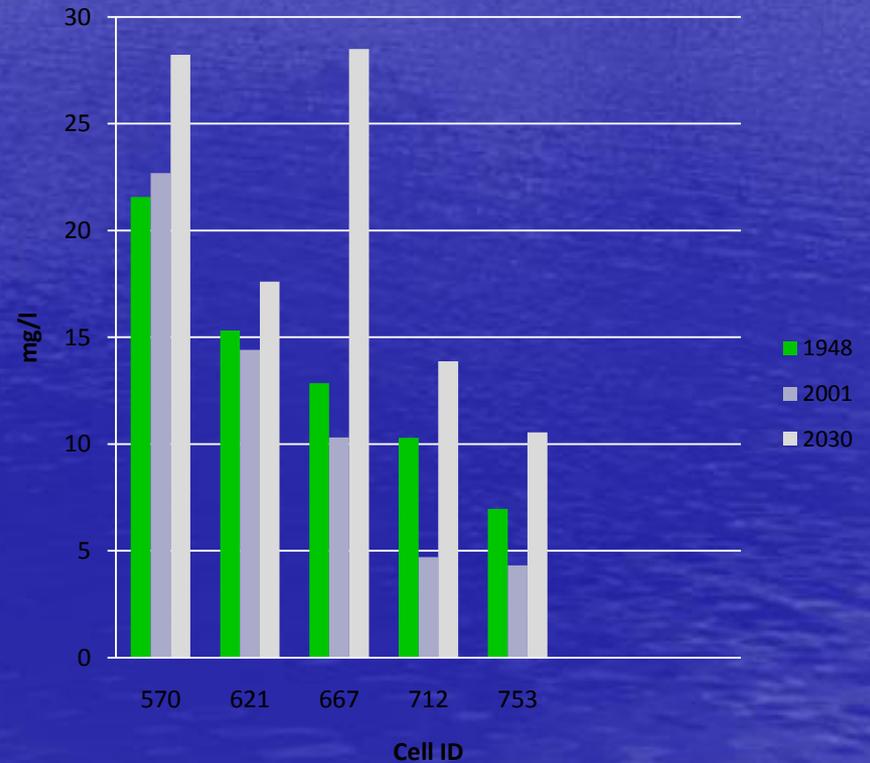


Average TSS in Shallow Aquatic Ecosystems

Average of All Layers Means TSS (Bayou La Batre)

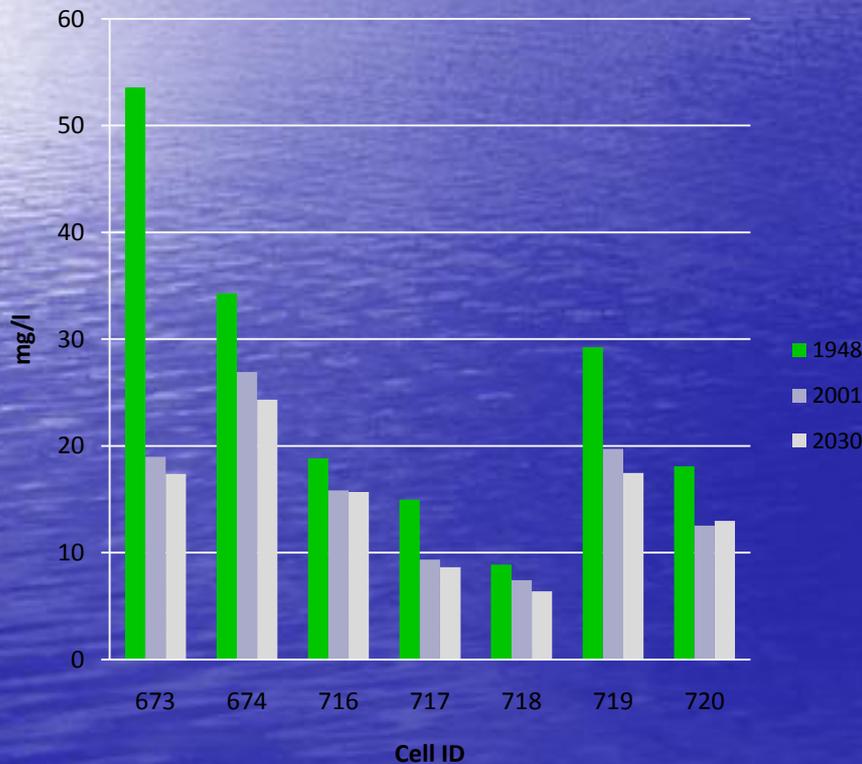


Average of All Layers Means TSS (Wolf Bay)

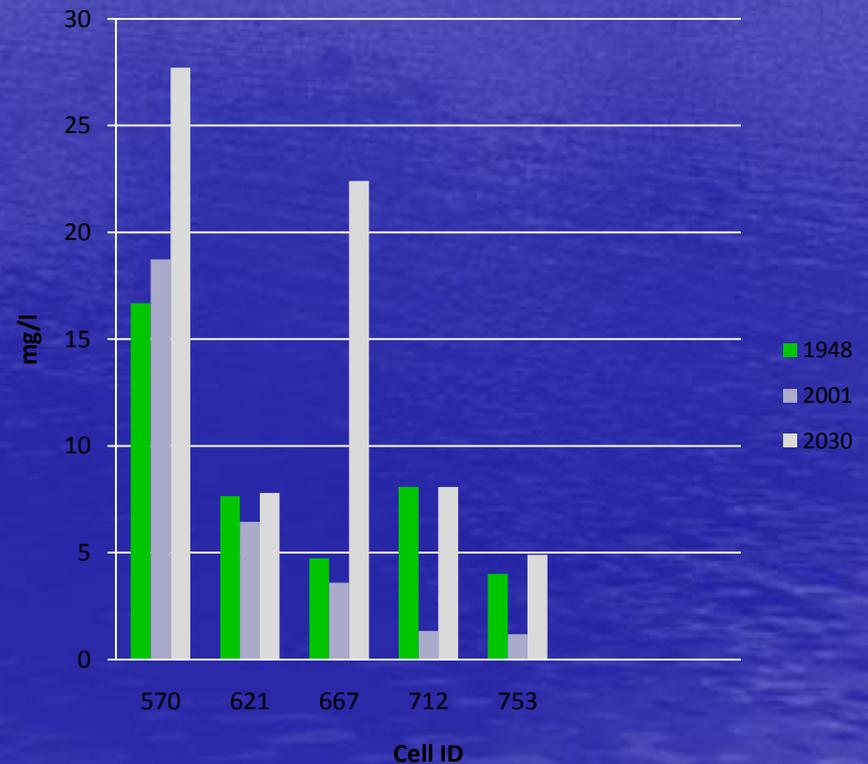


TSS Flux in Shallow Aquatic Ecosystems

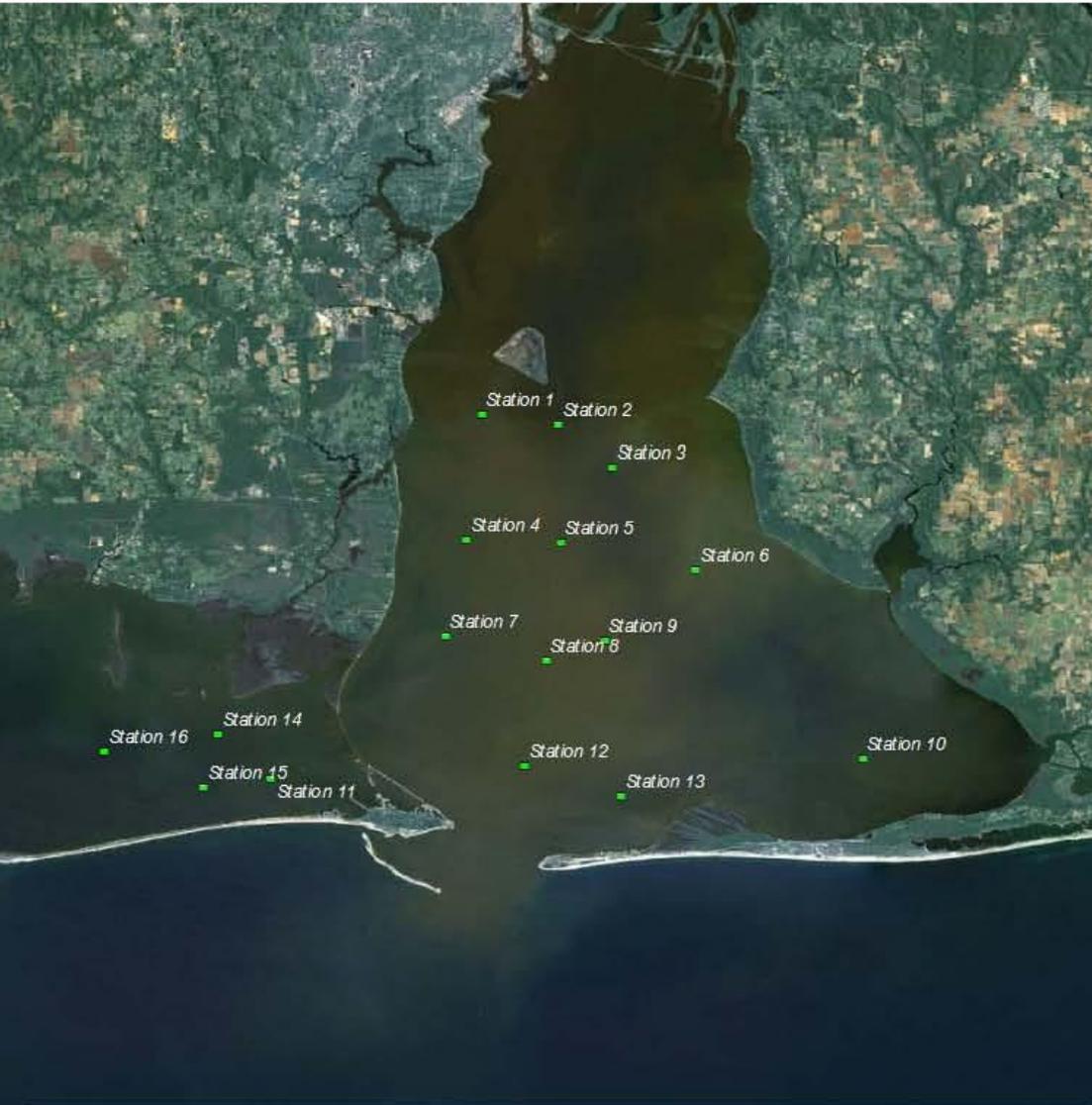
Standard Deviation of All Layers
Means TSS (Bayou La Batre)



Standard Deviation of All Layers
Means TSS (Wolf Bay)



TSS & Light Sampling Stations



Sample in-situ Data Readings TSS/Light

Steps to understanding how development may impact SAVs

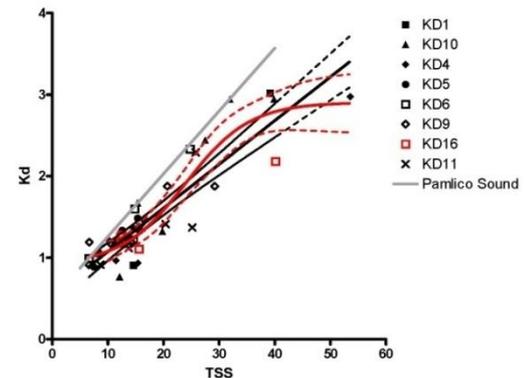
Develop Algorithm to Convert TSS to Kd

Use *in situ* data to develop regression equation between TSS values and the coefficient (K_d) which describes the rate of attenuation of light

Convert model values for TSS to Kd

Use algorithm to predict K_d values from modeled TSS concentrations

Evaluate predicted light levels with needed light levels



How would SAVs be impacted by the mean change in light?

- Suggested light limitation in Perdido Bay at levels less than 19% surface irradiance (SI) (Shafer 1999); 15-18% Texas

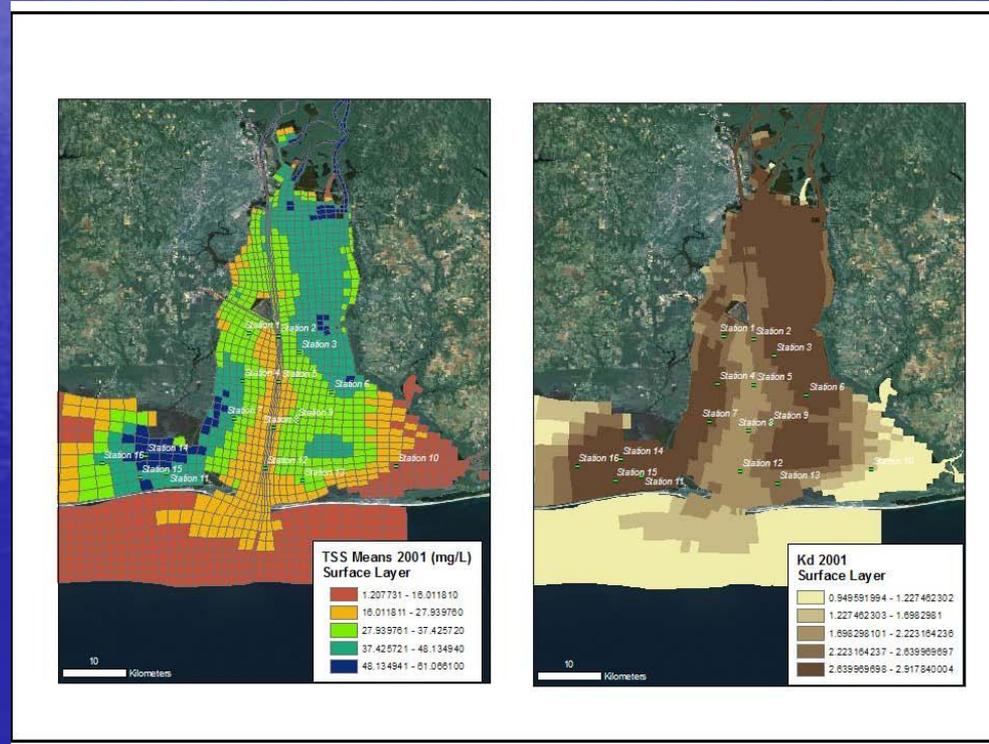
- Use Lambert – Beer's Law

$$\% SI = e^{-kz}$$

k = attenuation
coefficient (derived)

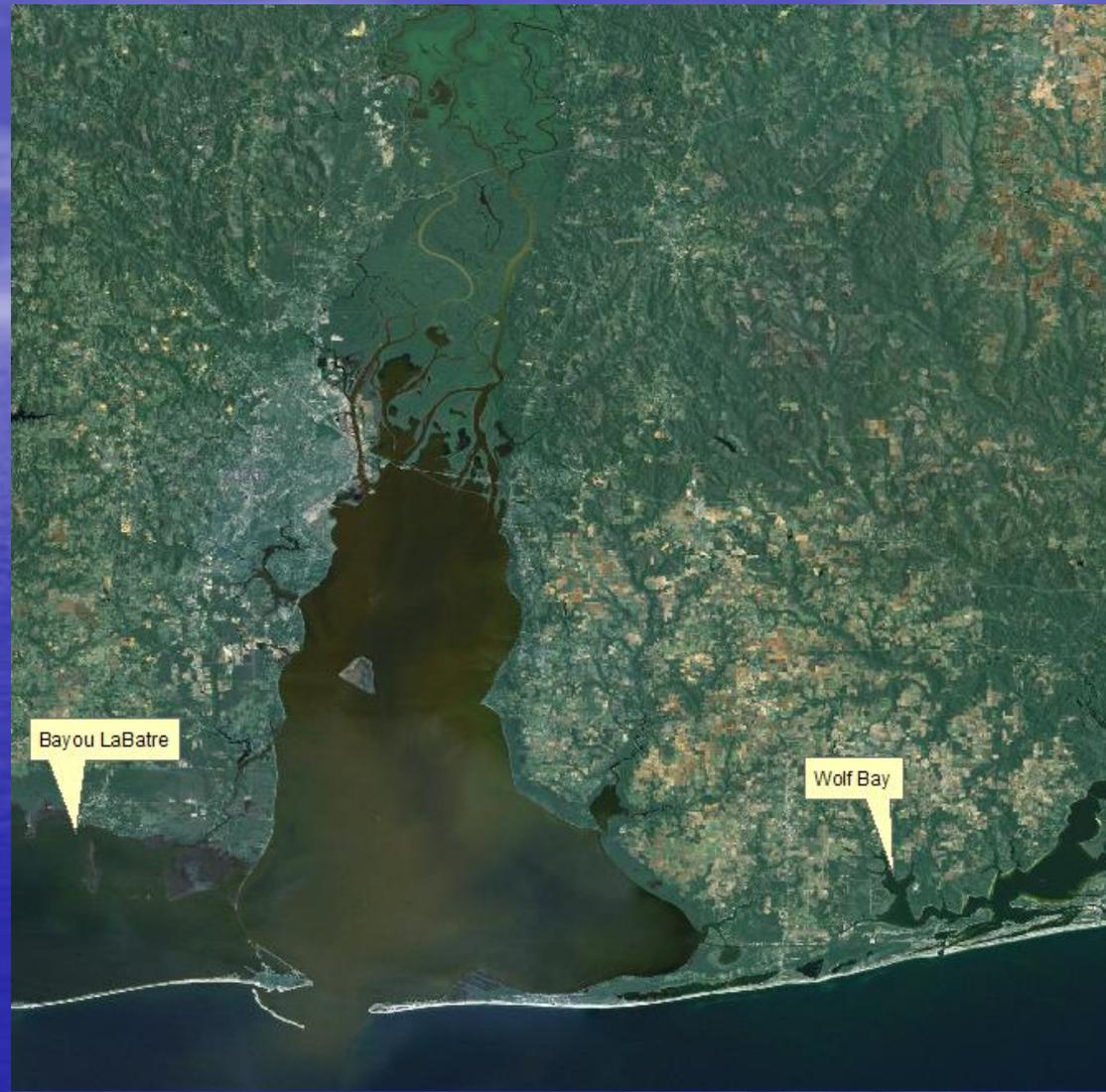
z = depth

To find depth limits at each
time step (1948, 2001,
2030)



Results

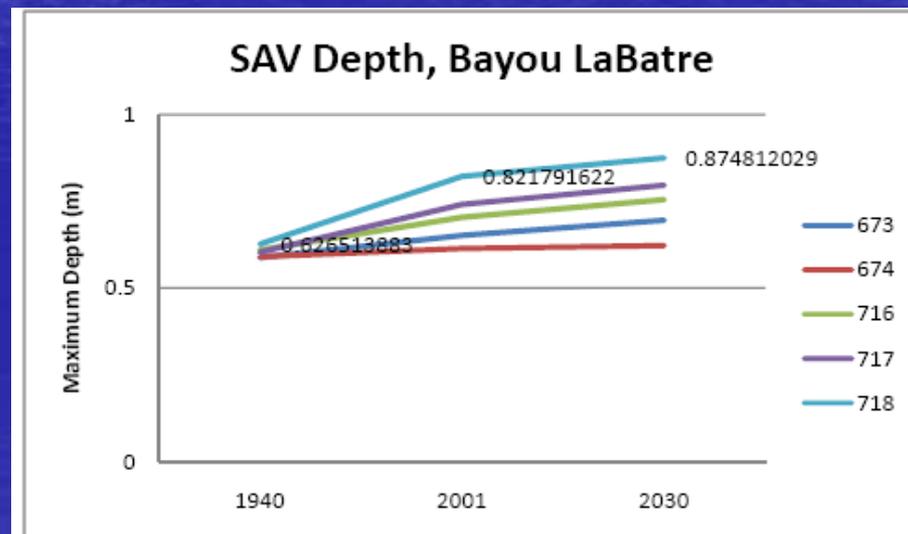
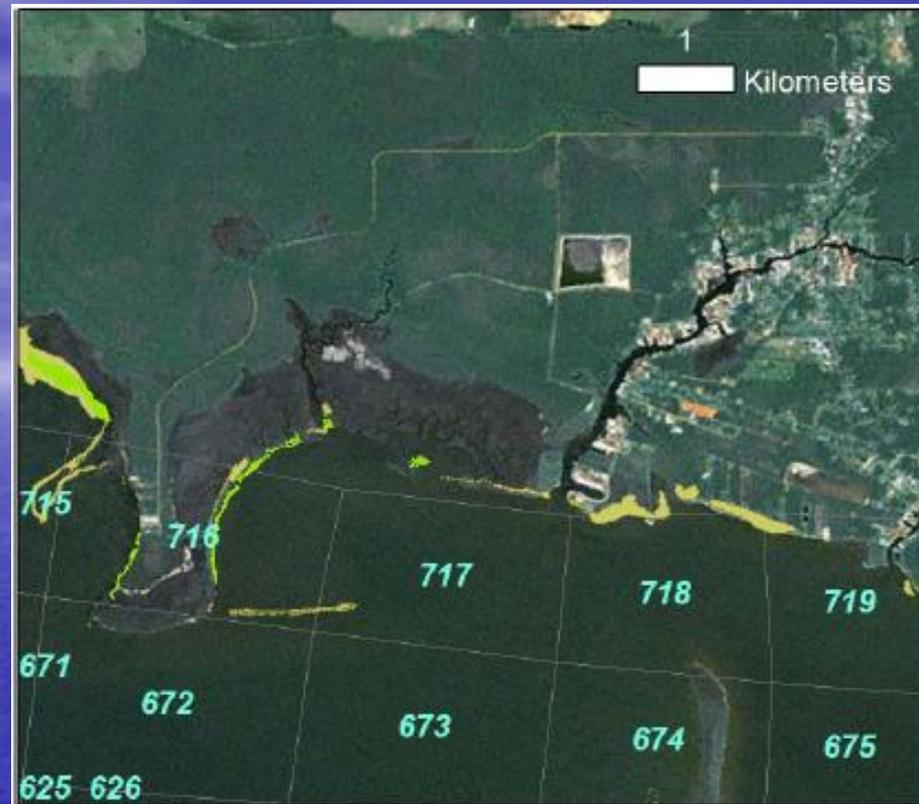
- Two sites studies have predicted changes in maximum SAV depth > .1m
 - Bayou La Batre
 - Wolf Bay



Bayou La Batre

Clearer water, more habitat

In Bayou La Batre, the maximum depth at which SAVs grow is predicted to increase from 1948 -2030, potentially expanding its range.



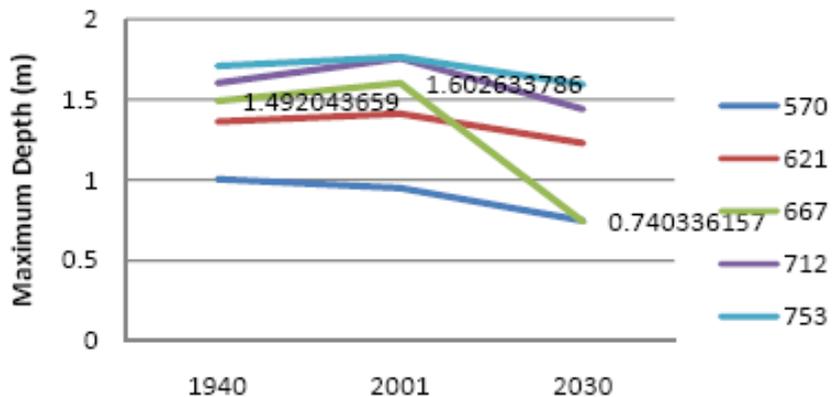


Wolf Bay

More turbidity, less habitat

In Wolf Bay, the maximum depth at which SAVs grow is predicted to decrease from 1948 -2030, potentially decreasing its range.

SAV Depth, Wolf Bay



Application of Research Results



Conclusions

- Land use changes are increasing freshwater flows into Mobile Bay.
- These increasing freshwater flows are causing increased fluctuations of temperature, salinity, and TSS.
- Seagrasses and SAVs have decreased in Mobile Bay over the past 60 years.
- Greatest impact of land use change could potentially be on highly dynamic edge areas.
- It is likely that understanding the frequency of light limiting events rather than the average amount of light will help our understanding of critical areas.
- This is cutting edge research that will benefit understanding and conservation of valuable coastal resources and benefit stakeholders.

Future Work

- Present research at the Oceans 2009 Marine Sciences Conference.
- Publish results late in 2009.
- More study areas around the Gulf of Mexico.
- Investigate the impact of climate variability and nutrient changes.

Thanks !

Maury.g.estes@nasa.gov

256-961-7735